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Boresighting and Weapon Checks with the Close-in Panel

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A specially designed "close-in panel" can be used in boresighting the turret weapons and sights of the Bradley Fighting Vehicle. This paper, seeking to address problems that arise in boresighting, describes developed/modified design for the panel, boresighting procedures, guidelines for making the panel, and procedures for conducting critical weapon system checks, including those for backlash, drift, equilabrator, and boresight retention.

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Boresighting and Weapon Checks with the Close-in Panel

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FOREWORD

Since 1975 the Army Research Institute for the Behavioral and Social Sciences (ARI) has contributed to a program to define emerging problems and address critical issues affecting the Bradley Fighting Vehicle (BFV). Consistent with this mission, problem analysis revealed that the close-in boresight panel, used in restricted areas like the motor pool, was difficult to make and use as described in the BFV gunnery field manual (FM 23-1, 1987). This report describes a modified close-in panel and improved procedures for boresighting with it, as well as how to use the panel to conduct critical weapon checks and how to make it.

ARI's Fort Benning Field Unit, a division of the Training Research Laboratory, monitored the research reported here. ARI's mission is to conduct research of training and training technology using infantry combat systems and problems as mediums. The research task that supports this mission is titled "Advanced Methods and Systems for Fighting Vehicle Training," organized under the "Train the Force" program area. Sponsorship for this research is provided by a Memorandum of Understanding (effective 31 May 1983) between the U.S. Army Infantry School (USAIS), Training and Doctrine Command, Training Technology Agency, and ARI, which established how joint efforts to improve BFV tactical doctrine, unit, and gunnery training would proceed.

The results of this research were briefed to the U.S. Army Infantry School, the Commander, 29th Infantry Regiment and the Bradley instructors throughout the 1st Battalion, 29th Infantry Regiment. The material has been incorporated as Appendix C in the Bradley gunnery manual, FM 23-1.

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BORESIGHTING AND WEAPON CHECKS WITH THE CLOSE-IN PANEL

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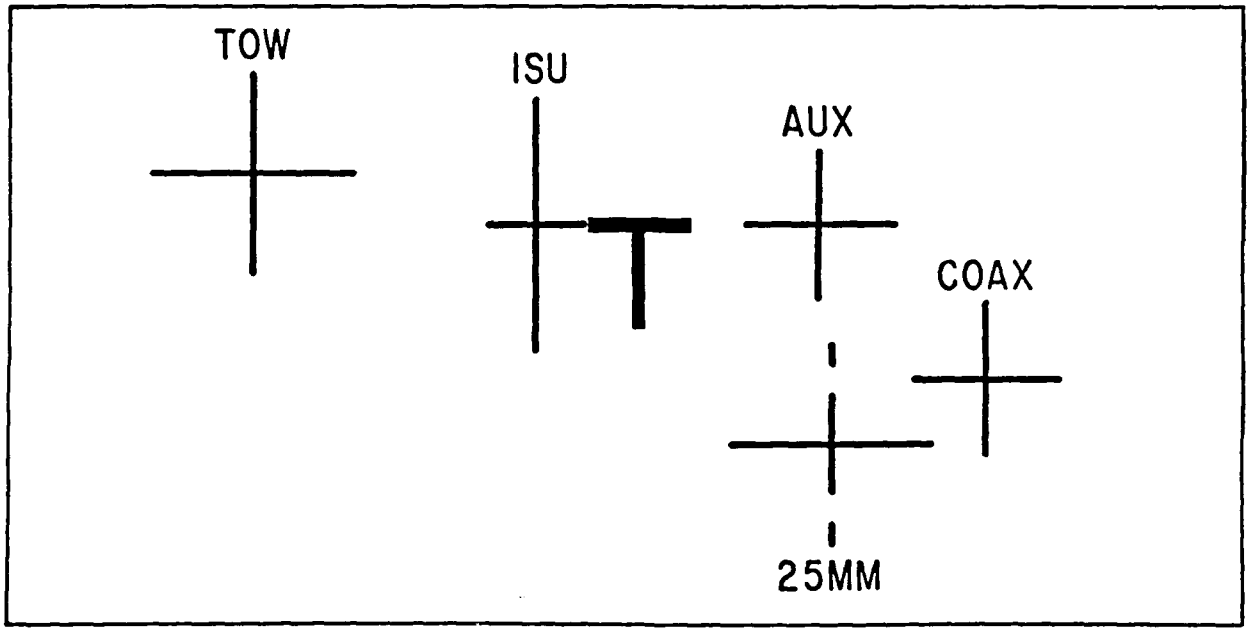
BORESIGHTING AND WEAPON CHECKS WITH THE CLOSE-IN PANEL

Section 1. INTRODUCTION

1. The close-in boresight panel is used to boresight BFV turret weapons in a restricted or confined area like the motor pool. Reference crosses are labelled TOW, ISU, AUX, 25MM, and COAX. A sixth reference is "T" shaped and made of metal to allow boresighting of the thermal sight. The background color of the panel is white. The ISU cross and "T" are black while the TOW, 25MM, COAX, and AUX crosses are orange. Section 2 describes how to setup the panel while Section 3 provides the step-by-step procedures for boresighting turret weapons and sights with the close-in boresight panel. Section 8 describes the dimensions and features of the panel in addition to procedures for making the panel.



2. The close-in boresight panel is also used to test:

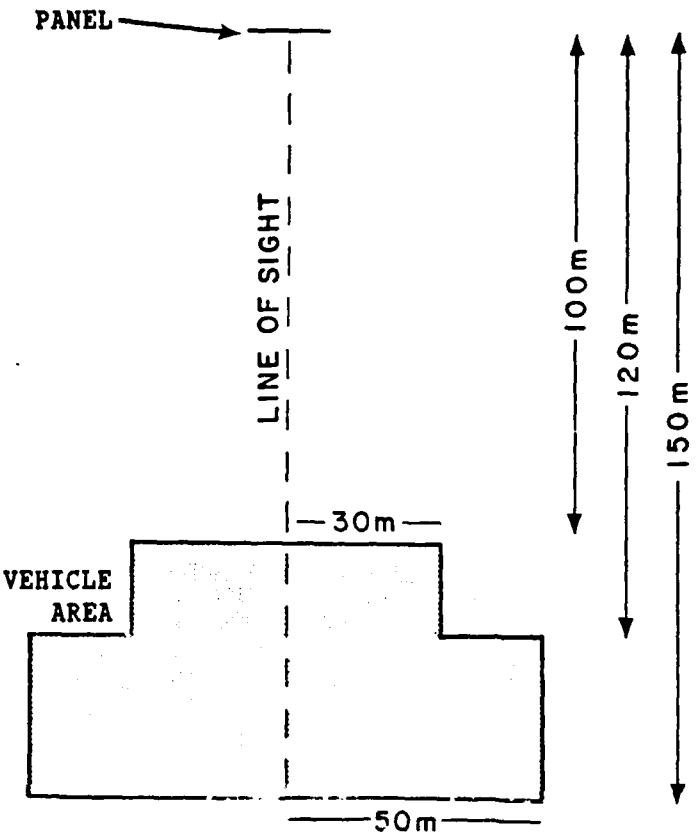
   - o Backlash (see Section 4).
   - o Equilibrator (see Section 5).
   - o Drift (see Section 6).
   - o Boresight retention (see Section 7).

   These tests allow the BFV crew (a) to identify weapon system errors that decrease firing accuracy and (b) to become more familar with their weapons. Tests for backlash, the equilibrator, and drift should be conducted in the motor pool in preparation for live-fire. Information on boresight retention is important for deciding when weapons should be reboresighted.

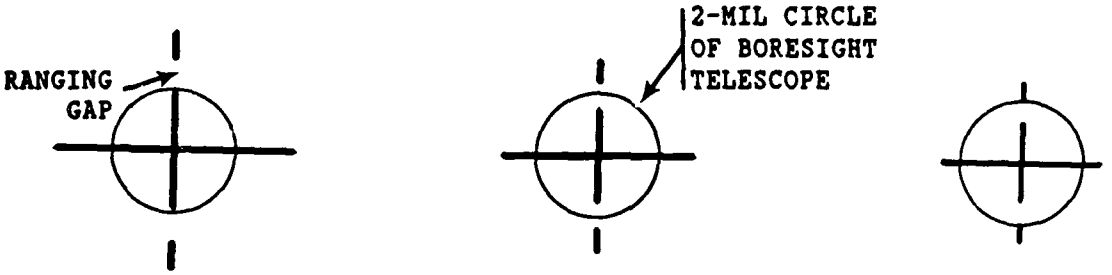
Section 2. PANEL SETUP

1. Depending on the positioning of vehicles and the panel in the motor pool, it may be possible to boresight equipment of an entire battalion with one panel. The drawing shows an overhead view of panel placement and location of vehicles.

2. Vehicles can be up to 30 meters right or left for direct line distances of 100 to 120 meters. For direct line distances of 120 to 150 meters, vehicles can be 50 meters to the right or left. The panel can be placed from 0 to 25 meters above ground level. This allows panel placement on top of a building or on the side of a tower.



3. Direct line distance is determined when the panel is first placed in the motor pool. A boresight kit is inserted into the 25-mm gun of a vehicle positioned on a direct line with the panel. The boresight reticle then is aligned with the 25MM cross on the panel. Ranging gaps in the 25MM cross are used to determine the panel's distance. Vehicles are at a correct distance if the 2-mil circle of the boresight reticle is (a) on the edge of or (b) in the gaps of the 25MM cross. The following are examples of vehicles at correct distances for boresighting.



100 METERS | BETWEEN 100 AND 150 METERS | 150 METERS

Section 3. BORESIGHTING

1. Preparation. Crews should be familiar with boresight procedures described in TM 9-2350-252-10-2. All turret weapons must be mounted and operational. A boresight kit and turret tool kit are required. The following checklist is used to prepare for boresighting with the close-in boresight panel:

___ Master power on

___ Turret power on

___ Night vision power switch turned on

___ Turret, gun, and TOW select levers in power (to raise TOW launcher)

___ TOW launcher raised

___ Turret azimuth select lever in manual

___ Gun elevation select lever in manual

___ TOW elevation drive select lever in power

___ Day and thermal ballistic sight cover doors open

___ Sensor select switch set on Neutral

___ Range control knob set at 0

___ Reticle brightness turned all the way to the right

___ Magnification set on high

___ AP or HE selected on weapons control panel

___ Status indicator displays ammunition and range index

___ Gun reticle is displayed

___ Turret travel lock disengaged

2. Boresight Kit Accuracy Test. The accuracy of the 25-mm boresight kit should be tested before boresighting.

NOTE: To prevent the 25-mm adapter from sticking or freezing in the gun barrel, apply a light coat of GMD on the end of the adapter and twist the adapter during insertion.

a. Helper installs the 25-mm boresight adapter and hangs the red streamer on the adapter.

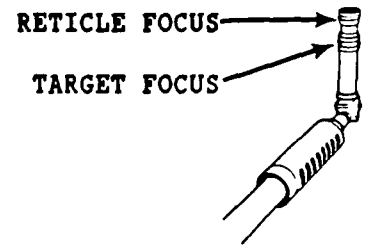
b. Helper installs and focuses the boresight telescope.

(1) Insert the shank of the telescope into the adapter until seated.

(2) Turn the reticle focus until the boresight reticle appears clear and sharp.

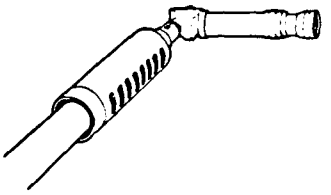
(3) Tell gunner to lay the gun until the target is visible through the boresight telescope.

(4) While looking at the reticle and moving your head slightly from side to side, turn the target focus until there is no movement between the reticle and target.

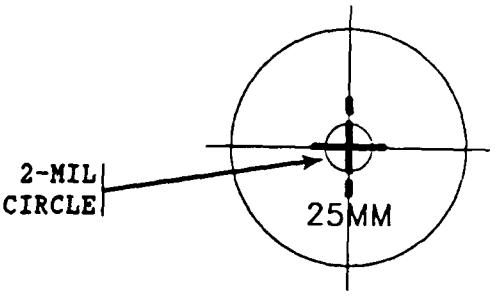


c. Helper checks accuracy of boresight kit.

(1) Rotate the telescope so that the eyepiece is facing right.

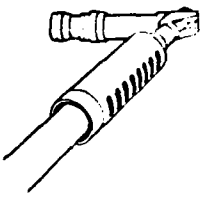


(2) Tell gunner to use the handwheels to lay the boresight cross hair on the 25MM cross on the panel.

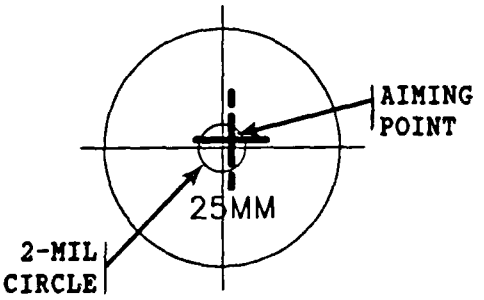


NOTE: During rotation of the kit, hold both the telescope and adapter to keep the telescope from slipping in the adapter.

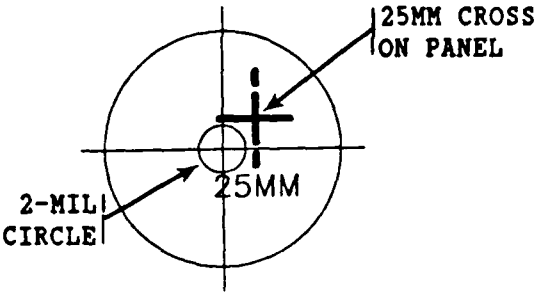
(3) Rotate both the telescope and adapter until the telescope is facing left.



(4) If the aiming point is inside or on the 2-mil circle off the boresight reticle, go to Lay the 25-mm gun.



(5) If the aiming point is outside the 2-mil circle the boresight reticle, then obtain another boresight kit and repeat substeps (1) through (4).



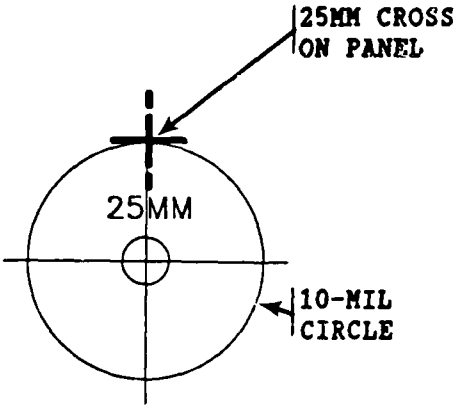
3. Lay the 25-mm gun.

a. Helper rotates the telescope until the eyepiece is facing up.

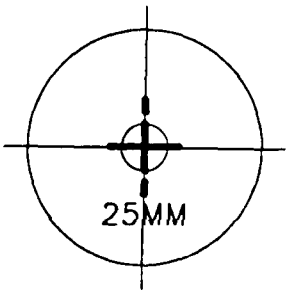
NOTE: The gun lay pattern should end in elevation to control for backlash.

b. Helper aligns the boresight reticle with the 25MM cross on the panel.

(1) Tell gunner to align the top of the 10-mil circle of the boresight reticle with the 25MM cross on the panel.



(2) Tell gunner to align the boresight cross hair with the 25MM cross on the panel.



NOTE: Do not traverse the turret or elevate/depress the gun until it is time to align the TOW missile system.

4. Align the ISU day reticle

NOTE: The neutral sensor select setting is better on bright or sunny days.

a. Move the sensor select switch (Clear or Neutral) to produce the best view of the ISU reticle and panel.

b. Align the ISU reticle with the ISU cross on the panel using the AZ and EL boresight adjustment knobs.

NOTE: When the panel is from 100 to 150 meters away; head movement on the browpad changes the aim of the reticle. For example, moving the head to the left shifts the aim to the left. Correct adjustment of the browpad is necessary when using the close-in panel.

c. Adjust the browpad.

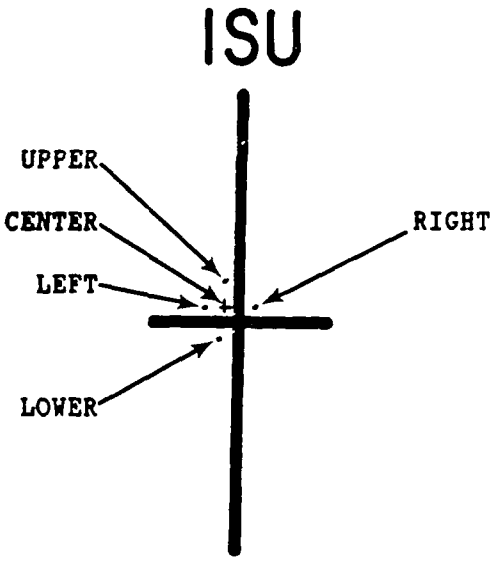
(1) Move head to the left until the sight begins to blackout and note the aiming point of the reticle; this aiming point is called the left limit.

(2) Move head to the right and note the right limit of the reticle.

(3) Move head up and note the upper limit of the reticle.

(4) Move head down and note the lower limit of the reticle.

(5) Adjust the browpad so that the reticle appears centered between the left, right, up, and down limits.



NOTE: If the ISU reticle is not aligned with the ISU cross, the reticle will require re-alignment.

d. If necessary, re-align the ISU reticle with the ISU cross using the AZ and EL boresight knobs.

5. Align the auxiliary sight

a. Focus sight with the eyepiece diopter.

b. If necessary, align the cross of the auxiliary sight with the AUX cross on the panel.

(1) Loosen locknut.

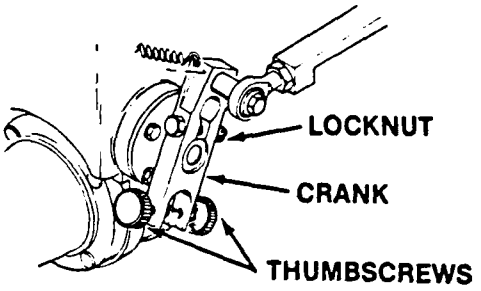
(2) Adjust thumbscrews to align the level (runs right and left) line of the reticle cross hair with the level line of the AUX cross on the panel.

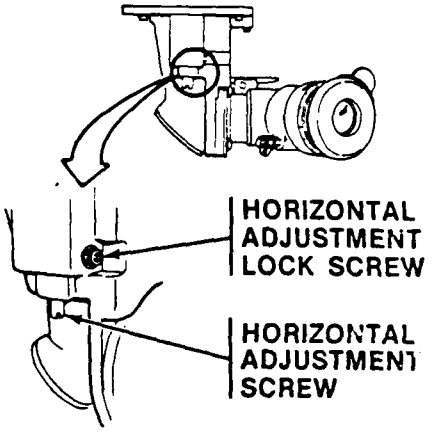
(3) Tighten the locknut.

(4) Loosen horizontal adjustment lock screw by about one-half to the left.

(5) Turn horizontal adjustment screw to align the upright line of the reticle cross hair with the upright line of the AUX cross on the panel.

(6) Tighten the horizontal adjustment lock screw.





6. Align the 7.62-mm coax machine gun

a. Select ammunition.

(1) Press the 7.62 button on the weapon control box.

(2) Check that 7.62 appears on status indicator.

b. Helper inserts the 7.62-mm adapter and boresight telescope into the coaxial machine gun.

c. Helper aligns the boresight reticle with the COAX cross on the panel.

(1) Tell gunner to use the AZ knob on the gun to align the boresight AZ cross hair (runs up and down) with the upright line on the COAX cross.

(2) Tell gunner to use the EL knob on the gun to align the boresight EL cross hair (runs right and left) with the level line on the COAX cross.

7. Align the ISU night reticle

a. Move sensor select switch to NIGHT.

NOTE: Use of black hot makes it easier to see the ISU reticle on the "T" of the panel.

b. Set the polarity switch (PLRT) on black hot (BH).

c. Adjust the thermal sight until the "T" is clearly visible.

(1) Turn the CON knob all the way to the right.

(2) Turn the BRT knob all the way to the left.

(3) Turn the BRT knob to the right until the "T" on the panel is seen.

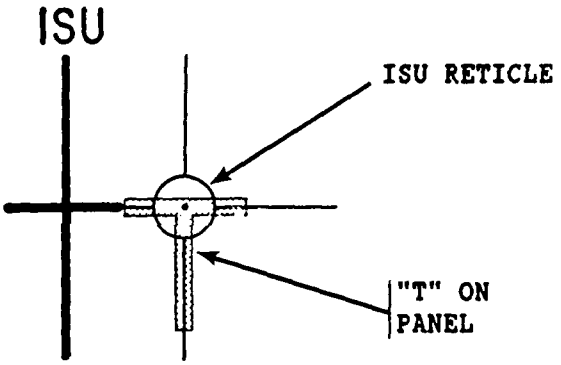
(4) Focus on the "T" using the focus ring.

(5) Turn the CON knob about one-quarter turn to the left.

(6) Turn BRT knob to the right until the "T" becomes clearer.

(7) Repeat focus ring, CON knob, and BRT knob adjustment, if necessary.

d. Align the ISU reticle with the "T" on the panel using the night boresight EL and AZ knobs.



8. <u>Align the TOW missile system</u>

a. Move the sensor select switch to clear or neutral.

b. Place the 25-mm gun elevation select lever in the power mode.

c. Place the TOW elevation select lever in the manual mode.

d. Helper inserts the boresight telescope into the alignment hole between the TOW launcher tubes.

e. Press the TOW button.

f. Check that the TOW indicator light goes out when the self-test is completed.

g. Check that TOW appears on status indicator.

h. Helper aligns the boresight reticle with the TOW cross on the panel.

(1) Tell gunner to traverse to align the boresight AZ cross hair (runs up and down) with the upright line of the TOW cross.

(2) Tell gunner to elevate or depress to align the boresight EL cross hair (runs right and left) with the level line of the TOW cross.

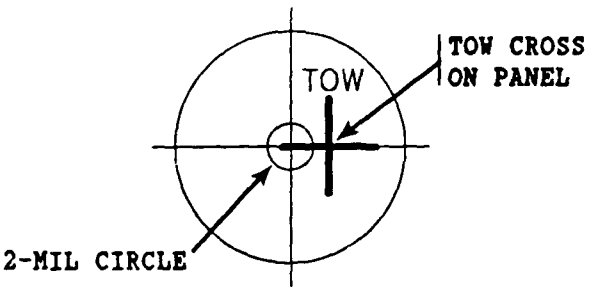
i. Align the TOW reticle EL cross hair (runs right and left) with the level line on the ISU cross of the panel using the TOW boresight screw.

j. Traverse to align the TOW reticle with the ISU cross on the panel.

k. Determine launcher alignment error.

(1) Observe the aiming point of the boresight reticle on the TOW cross of the panel.

(2) Estimate distance (mils) between the boresight reticle and TOW cross using the 2-mil circle of the boresight reticle.



1. ~~(12)~~ If the error is more than 1 mil, adjust the launcher as described in TM 9-2350-252-10-2.

Section 4. BACKLASH TEST

1. Background. When the direction of gun elevation is reversed (for example, the gun is depressed after it was just elevated), the sight may not immediately move with the gun. This slack between the sight and gun is called backlash. Backlash is controlled during boresighting by using a gun lay ending in elevation (Section 2, Lay the 25-mm gun, step 3). To prevent gunnery errors caused by backlash, targets should also be engaged using a gun lay ending in elevation. Separate backlash testing procedures are described for the ISU and auxiliary sight.

2. Procedure. The 25-mm gun, ISU day reticle, and auxiliary sight must be boresighted as described in Section 2 before backlash is tested. Weapon, sight, and turret controls are the same as following boresighting.

   a. **Measuring ISU backlash**

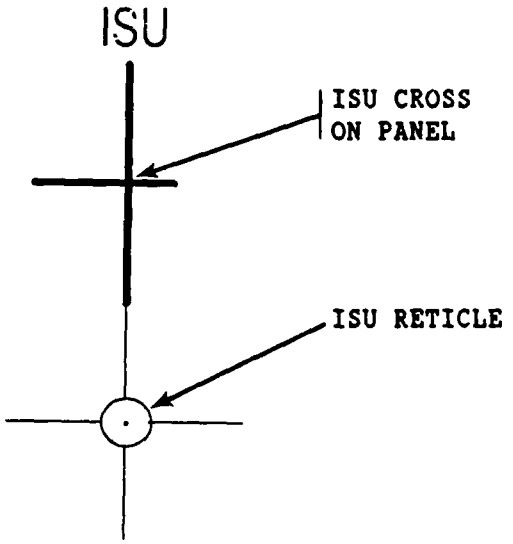
      (1) If necessary, select AP-SS on the weapon control box.

      (2) Insert the 25-mm adapter and boresight telescope into the 25-mm gun.

      NOTE: If necessary, focus the telescope (see step 2.b of Section 3).

      (3) Align the ISU reticle with the ISU cross on the panel using gun and turret handwheels.

      (4) Depress the gun. Use the gun handwheel to depress the gun until the top of the ISU reticle touches the bottom of the ISU cross on the panel.

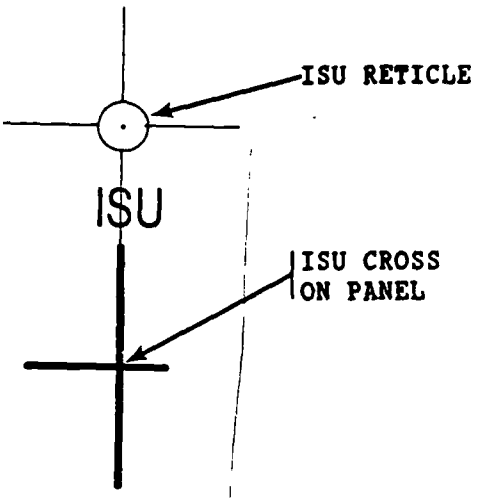


      (5) Elevate the gun to align the ISU reticle with the ISU cross on the panel.

      NOTE: Do not move or remove the 25-mm boresight kit until backlash testing is completed.

(6) Helper notes the aiming point of the boresight reticle on the 25MM cross.

(7) Elevate the gun. Use the gun handwheel to elevate the gun until the bottom of the ISU reticle touches the top of the ISU cross on the panel.



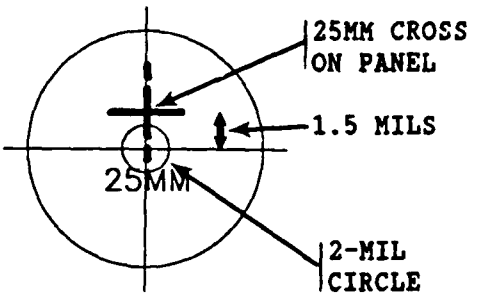
(8) Depress the gun to align the ISU reticle with the ISU cross on the panel.

(9) Helper observes the aiming point of the boresight reticle on the 25MM cross.

(10) Measure backlash.

(a) Helper notes the location of the boresight reticle and the 25MM cross.

(b) Helper uses the 2-mil circle of the boresight reticle to estimate the distance (mils) between aiming points observed in elevation and depression (compare observations during steps (6) and (9)).



NOTE: The backlash for the example is 1.5 mils.

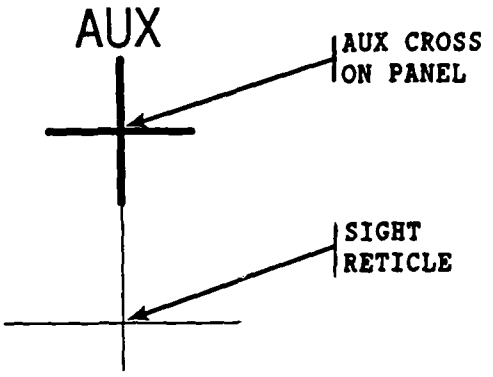
(c) Notify organizational maintenance if backlash is more than 2 mils.

b. Measuring auxiliary sight backlash

(1) Insert the 25-mm adapter and boresight telescope into the 25-mm gun.

(2) Align the auxiliary sight cross with the AUX cross on the panel using the turret and gun handwheels.

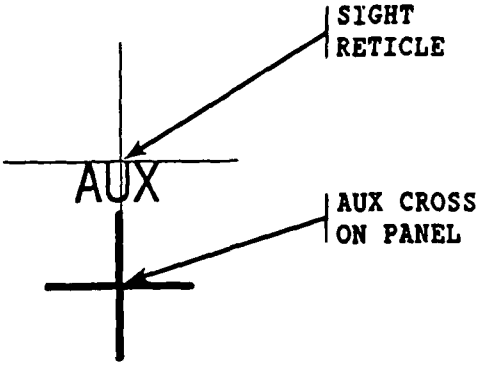
(3) Depress the gun. Use the gun handwheel to depress the gun until the top of the auxiliary sight reticle touches the bottom of the AUX cross on the panel.



(4) Elevate the gun to align the auxiliary sight reticle with the AUX cross on the panel.

(5) Helper notes the aiming point of the boresight reticle on the 25MM cross.

(6) Elevate the gun. Use the gun handwheel to elevate the gun until the bottom of the auxiliary sight reticle touches the top of the AUX cross on the panel.



(7) Depress the gun to align the auxiliary sight reticle with the AUX cross of the panel.

(8) Helper notes the aiming point of the boresight reticle on the 25MM cross.

(9) Measure backlash as described for the ISU. Backlash in mils is the difference in the aiming points observed during steps 5 and 8.

Section 5. EQUILIBRATOR TEST

1. Background. When the ISU reticle is laid on target in power mode, the aiming point should not change when the palm switches are released. The equilibrator may be faulty if the sight and the gun drop after the palm switches are released. The following is a check of the equilibrator.

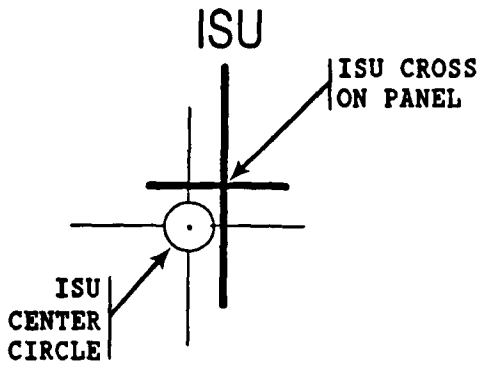
2. Procedure. The equilabrator test is conducted after boresighting and the backlash test.

   a. Align the ISU reticle with the ISU cross on the panel using the gunner's hand station.

   b. Release the palm switches.

   NOTE: Failure to pass the test may indicate a faulty equilibrator or a faulty gun elevation brake.

   c. Notify organization maintenance if the ISU center circle moves outside the ISU cross on the panel when the palm switches are released.



Section 6. DRIFT TEST

1. Background. When stabilization is turned on, the palm switches are depressed, and the BFV is stationary, the ISU gun reticle is allowed to drift from the aiming point no more than 0.1 mil per sec. A 5-sec test of drift is described.

2. Procedure. Drift is tested after the equilibrator test. Switch settings and vehicle conditions are the same as existing at the end of the equilibrator test.

   a. Turn stabilization on.

   b. Check that the stabilization indicator light comes on.

   c. Press the drift button.

   NOTE: Testing should be conducted within 1 minute after pressing the drift button.

   d. Align the ISU reticle with the ISU cross on the panel using the gunner's hand station.

   e. Start 5-second test.

      (1) Helper uses watch to signal start of test.

      (2) Gunner presses the palm switches while keeping the hand station in the neutral position.

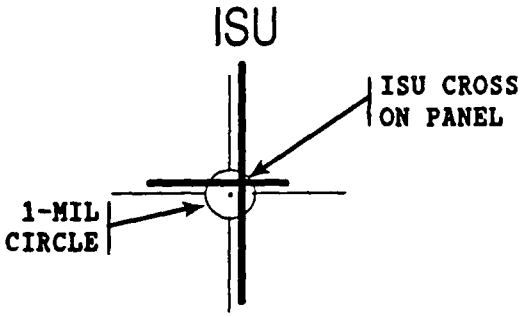
   f. Stop the test.

      (1) Helper signals end of 5-second test.

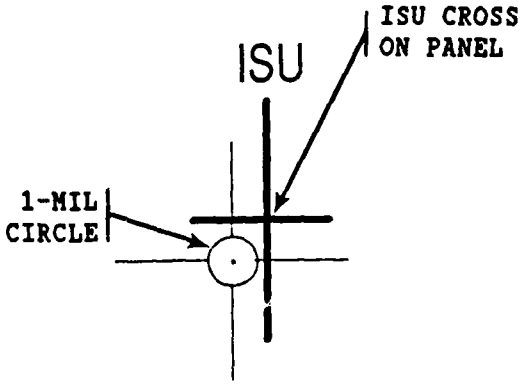
      (2) Gunner releases palm switches on helper's signal.

   g. Drift is scored.

      (1) The standard is met if the ISU cross of the panel is either on or within the 1-mil circle of the ISU reticle.



      (2) Notify organizational maintenance if the ISU cross of the panel is outside the 1-mil circle of the ISU reticle.



Section 7. BORESIGHT RETENTION TEST

1. Background

   a. After the 25-mm gun and ISU are boresighted, sight alignment is allowed to change no more than 0.25 mils for vehicle operation up to 50 miles, provided that the ambient temperature does not change more than 54 degrees (plus or minus) from that existing when boresighting was conducted. If boresight retention requirements are met, the weapon can be boresighted in the motor pool and the vehicle can move to a fighting position without the need to re-boresight before zeroing.

   b. Vehicles should be tested to ensure that boresight retention requirements are met. The most accurate boresight equipment should be used to test boresight retention. Because of potential boresight equipment errors, the boresight retention standard for field testing is 1 mil.

   c. Boresight retention can be measured during a tactical road march or any other movement exercise that does not require adjustment of the boresight knobs. Boresight retention can be measured following movement of any distance, movement does not have to be 50 miles. Testing allows crews to learn the conditions that lead to loss of boresight retention for their vehicle. This is critical for deciding when to re-boresight the weapons.

2. Procedure

   a. Identify a 25-mm boresight kit that passes the kit accuracy test.

   b. Conduct Preparation, Lay the 25-mm gun, and Align the ISU day reticle as described in Section 3.

   c. Tape the cover of the boresight knobs to prevent accidental movement or adjustment.

   d. Record distance traveled and temperature variations during vehicle operations.

   e. Test boresight retention.

      (1) Return vehicle to same position that boresighting was conducted.

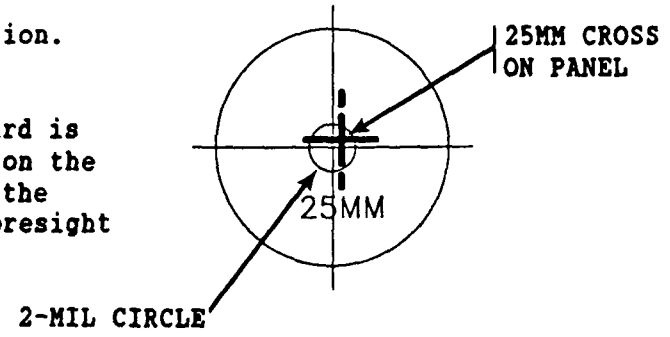
      (2) Conduct Preparation as described in Section 3.

      (3) Insert the boresight kit used in step a into the 25-mm gun.

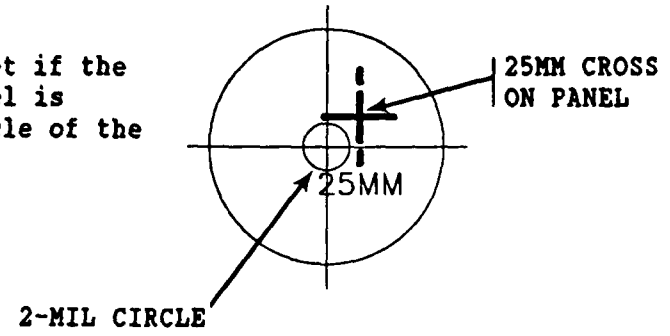
      (4) Align the ISU reticle with the ISU cross on the panel using a gun lay pattern ending in elevation.

(e) Determine boresight retention.

(1) The 1-mil field standard is met if the 25MM cross on the panel is on or within the 2-mil circle of the boresight telescope.



(2) The standard is not met if the 25MM cross of the panel is outside the 2-mil circle of the boresight telescope.



Section 8. MAKING THE PANEL

1. Panel Dimensions and Features

a. The close-in boresight panel is 4 feet by 8 feet. The location of the center of each cross is measured from the lower, left corner of the panel.

Table 1. Distance (inches) of crosses from lower, left corner of close-in boresight panel.

	Reference Cross					
Direction	TOW	ISU	T	AUX	25MM	COAX
Right	19	41	49	63	64	74
Up	35	31	31	31	14	19

b. The lines of all crosses, except the "T", are 1/2 inches wide. The 1 inch lines of the "T" are made of steel scewed on the panel to allow a good image for thermal boresighting. Lines are either black or orange. Crosses viewed with a black reticle (boresight telescope and auxiliary sight) are orange. The two references (ISU and "T") viewed using the 25-mm reticle are black.

Table 2. Color of crosses and width of lines

	Reference Cross					
Feature	TOW	ISU	T	AUX	25MM	COAX
Color	Orange	Black	Black	Orange	Orange	Orange
Width (in)	1/2	1/2	1	1/2	1/2	1/2

c. The length of each arm on the crosses is given below. The 8 inch upper and lower lines of the 25MM cross has ranging gaps from 4 to 6 inches from the center of the cross.

Table 3. Length of the lines on crosses

	Reference Cross					
Arm	TOW	ISU	T	AUX	25MM	COAX
Upper	8	10	0	6	8	6
Lower	8	10	8	6	8	6
Right	8	4	4	6	6	6
Left	8	8	4	6	6	6

2. Materials and Supplies

a. The following procedure allows construction of the panel by any person who can measure, paint, and use a router. Painting the 1/2 wide lines for the crosses is simplified using a router to cut grooves that form the crosses. The grooves are then painted.

b. Supplies

- o 3/4-inch X 4-foot X 8-foot exterior plywood, A/C or B/C.
- o A 15 1/2-inch-long strip of 1-inch-wide steel.
- o 4 number 6, 3/4-inch-long, flat-head wood screws.
- o 1 quart of white primer, exterior (oil or alkyl base).
- o 1 quart of white paint, exterior (latex or oil base).
- o 1 pint of black paint, exterior (latex or oil base).
- o 1 pint of bright orange paint, exterior (latex or oil base).
- o Paint thinner or brush cleaner.
- o Medium grit sand paper.
- o If the names of crosses are not painted on, then 3-inch vinyl stick on letters to spell TOW, ISU, AUX, 25MM, and COAX.

c. Equipment

- o 8-foot straight edge.
- o 2 C-clamps.
- o Framing square.
- o 8-foot (or longer) tape measure.
- o 6-inch or 8-inch paint pad or a paint brush.
- o 3/8-inch paint brush.
- o A router and a 1/2-inch straight router bit.
- o Power drill and a 1/4-inch bit.
- o Pencil.

d. Procedure

(1) Sand the front, back, and edge of plywood to remove dirt and grease.

(2) Mark the words "LOW, LEFT" on the lower, left-hand corner of the panel.

(3) To mark the TOW cross using a pencil and the 8-foot straight edge,

(a) Make a mark 19 inches to the right of the lower, left edge of the panel (A).

(b) Make a mark 19 inches to the right of the upper, left edge of the panel (B).

NOTE: Table 1 on page 8-1 shows that the TOW cross is 19 inches right from the left edge of the panel.

(c) Draw a line connecting the two marks at A and B.

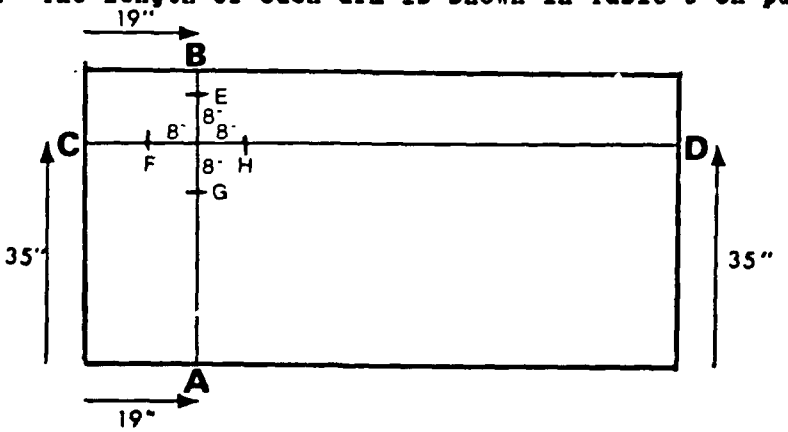
(d) Make a mark 35 inches up from the lower, left edge of the panel (C).

(e) Make a mark 35 inches up from the lower right edge of the panel (D).

(f) Draw a line connecting the two marks made at C and D.

(g) Make marks 8 inches from the center of the cross formed by lines drawn (E, F, G, and H).

NOTE: The length of each arm is shown in Table 3 on page 8-1.



(4) To mark the ISU, AUX, 25MM, and COAX crosses, use the following procedure:

(a) Using the data from the Right Direction row of Table 1, mark the vertical lines of the crosses as described above for the TOW cross (see substeps (a), (b), and (c)).

(b) Using the data from the Up Direction row of Table 1, mark the horizontal lines of the crosses as described above for the TOW cross (see substeps (d), (e), and (f)).

(c) Mark the length of each arm of each cross using data from Table 3.

(5) Rout the crosses by performing the following for each cross:

(a) Set router depth shallow (1/32 or 3/64 inch) so that it will not cut through the first layer of the plywood.

(b) Clamp the straight edge to the wood to serve as a guide for the router.

(c) Use the router to cut grooves for the lines of the cross.

NOTE: Cutting is performed between the tick marks that show the length of each arm of the cross.

(6) Apply a coat of primer to the front, back, and edge of the panel. Make sure that paint does not run into or build up in the grooves.

(7) Apply a coat of white paint to the entire panel.

(8) Paint the crosses using the 3/8 inch paint brush and colors described in Table 3.

(9) Make the "T" as follows:

(a) Cut the steel strip into one 8-inch section and another 7 1/2-inch section using the jig saw.

(b) Drill two 1/4 inch wide holes in each of the two sections: each hole is placed 1 1/2 inches from the end.

(c) Apply a coat of primer paint.

(d) Apply a coat of black paint.

(10) Mount the "T".

(a) Lay a straight edge along the right arm of the ISU cross.

(b) Draw a 9-inch line along the straight edge starting at the edge of the right arm.

(c) Align the 8-inch strip of steel on the line; the left edge of the strip touches the right edge of the right arm of the ISU cross.

(d) Mount the strip using 2 wood screws.

(e) Center the 7 1/2-inch strip underneath the 8-inch strip to form the letter "T".

(f) Mount the 7 1/2 strip using 2 wood screws.

(11) Label the crosses using the vinyl letters and numbers. Apply labels as shown in the figure of the panel on page 1.